UNIT # 3
DYNAMICS

Q1. Define dynamics?

Ans: Dynamics:

The branch of mechanics that deals with the study of motion of an object and the cause of its motion is called **dynamics**.

Q2. Define force.

Ans: Force:

A force moves or tends to move, stops or tends to stop the motion of a body. The force can also change the direction of motion of a body.

$$F = ma$$

SI unit of force is newton.

Note: A force can also change the shape or size of a body on which it acts.

Q3. Define inertia. Perform an experiment to understand inertia?

OR

What is the law of inertia?

Ans: See Q # 3.4 from Exercise.

Q4. Put a one rupee coin over a piece of card paper placed on an empty glass. Push the card with a sudden stroke of finger. Card will move ahead while the coin falls in the glass. Why it does so?

Ans: Due to inertia card will continue its motion in the forward direction while coin will remain at rest and will fall in the glass.

Q5. Define momentum.

Ans: Momentum:

Momentum of a body is the quantity of motion it possesses due to its mass and velocity.

The momentum P of a body is given by the product of its mass m and velocity v. Thus

$$P = mv$$

Momentum is a vector quantity. Its SI unit is $kgms^{-1}$.

Momentum of a system depends on its mass and velocity.

Q6. A bullet has a very small inertia due to its small mass. But why does its impact is so strong when it is fired from the gun?

Ans: According to the law of conservation of momentum mass of bullet is much smaller than the gun therefore the recoil is much greater than the velocity of gun. Therefore the impact of bullet is very strong.

Q7. Why the impact of a loaded truck on a body coming its way is very large even if the truck is moving slowly.

Ans: Greater is the mass of truck greater will be its momentum. Therefore loaded truck has large impact.

Q8. Explain Newton's first law of motion by practical examples of daily life?

Ans: Newton's laws of motion:

A body continues its state of rest or of uniform motion in a straight line provided no net force acts on it.

Examples:

Case I (Part I):

According to Newton's first law of motion, a body at rest remains at rest provided no net force acts on it. This part of the law is true as we observe that objects do not move by themselves unless someone moves them. For example, a book lying on a table remains at rest as long as no net force acts on it.

Case II (Part II):

Similarly, a moving object does not stop moving by itself. A ball rolled on a rough ground stops earlier than that rolled on a smooth ground. It is because rough surfaces offer greater friction. If there would be no force to oppose the motion of a body then the moving body would never stop.

Q9. Why Newton's first law of motion is also known as law of inertia?

Ans: Since Newton's first law of motion deals with the inertial property of matter, therefore, Newton's first law of motion is also known as law of inertia.

Q10. Why the passengers standing in a bus fall forward when its driver applies brakes suddenly?

Ans: The passengers standing in a bus fall forward when its driver applies brakes suddenly. It is because the upper parts of their bodies tend to continue their motion, while lower parts of their bodies in contact with the bus stop with it. Hence, they fall forward.

Q11. When a bus takes a sharp turn, passengers fall in the outward direction. Why?

Ans: When a bus takes a sharp turn, passengers fall in the outward direction. It is due to inertia that they want to continue to their motion in a straight line and thus fall outwards.

Q12. Define net force?

Ans: Net force:

Net force is the resultant of all the forces acting on a body.

Q13. State and prove Newton's second law of motion.

OR

Show that F = ma.

Ans: Newton's second law of motion:

When a net force acts on a body, it produces acceleration in the body in the direction of the net force. The magnitude of this acceleration is directly proportional to the net force acting on the body and inversely proportional to its mass.

Derivation of formula F = ma:

If a force produces an acceleration '*a*' in a body of mass '*m*', then we can state mathematically that

$$a \propto F \quad \text{.........(i)}$$

and

$$a \propto \frac{1}{m} \quad \text{.........(ii)}$$

By combining (i) and (ii)

or $$a \propto \frac{F}{m}$$

or $$F \propto ma$$

Putting k as proportionality constant, we get

$$F = kma \quad \ldots\ldots\ldots \text{(iii)}$$

In SI units, the value of k comes out to be 1. Thus Eq. (iii) becomes

$$F = ma$$

Q14. Define SI unit of force?

Ans: SI unit of force:

SI unit of force is newton (N).

Newton (1 N):

One newton (1 N) is the force that produces an acceleration of 1 ms^{-2} in a body of mass of 1kg.

Thus, a force of one newton can be expressed as

$$1\text{N} = 1\text{ kg} \times 1\text{ ms}^{-2}$$

or $$1\text{N} = 1\text{ kgms}^{-2}$$

Q15. Differentiate between mass and weight.

Ans: See Q # 3.3(i) from Exercise.

When a bus takes a sharp turn, passengers fall in the outward direction. It is due to inertia that they want to continue their motion in a straight line and thus fall outwards.

Q16. Explain Newton's third law of motion by practical examples of daily life?

Ans: Newton's third law of motion:

To every reaction there is always an equal but opposite reaction.

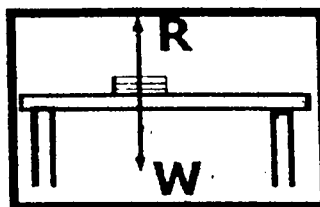
Explanation:

Newton's third law of motion deals with the reaction of a body when a force acts on it. Let a body A exerts a force on another body B, the body B reacts against this force and exerts a force on body A. The force exerted by body A on B is the **action force** whereas the force exerted by body B on A is called the reaction **force.**

Note that action and reaction forces act on different bodies.

Examples:

Book lying on a table:

Consider a book lying on a table.The weight of the book is acting on the table in the downward direction. This is the action. The reaction of the table acts on the book in the upward direction.

Action of the book and reaction on it

An air-filled balloon:

Take an air-filled balloon. When the balloon is set free, the air inside it rushes out and the balloon moves forward. In this example, the action is by the balloon that pushes the air out of it when set free. The reaction of the air which escapes out from the balloon acts on the balloon. It is due to this reaction of the escaping air that moves the balloon forward.

Taking off a rocket:

A rocket such moves on the same principle. When its fuel burns, hot gases escape out from its tail with a very high speed. The reaction of these gases on the rocket causes it to move opposite to the gases rushing out of its tail.

Quick Quiz

Stretch out your palm and hold a book on it.

1. How much force you need to prevent the book from falling?

Ans: The force which is needed to prevent the book from falling is equal to the weight of the book. i.e. $R = W$

2. Which is action?

Ans: The weight of the book acting in a downward direction is called action.

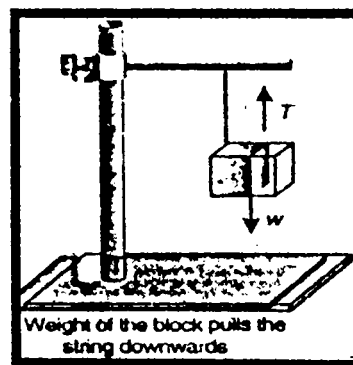
3. Is there any reaction? If yes, then what is its direction?

Ans: Yes, the force applied to prevent the book from falling is called the reactional force. The reactional force is acting in the upward direction. Opposite to the weight of book i.e. $R = W$

Q17. What do you know about tension and acceleration in a string?

Ans: Tension and acceleration in a string:

Consider a block supported by a string. The upper end of the string is fixed on a stand. Let w be the weight of the block. The block pulls the string downwards by its weight. This causes a **tension** T in the string. The tension T in the string is acting upwards at the block. As the block is at rest, therefore, the weight of the block acting downwards must be balanced by the upwards tension T in the string. Thus the tension T in the string must be equal and opposite to the weight w of the block.

Weight of the block pulls the string downwards

Q18. Calculate the tension and acceleration in a string during motion of bodies connected by the string and passing over frictionless pulley using second law of motion?

Ans: Vertical motion of two bodies attached to the ends of a string that passes over a frictionless pulley:

Suppose two bodies A and B having masses m_1 and m_2 respectively are connected to two ends of an inextensible string which passes over a frictionless pulley. If m_1 is greater than m_2, then the body A will move downward and the body B will move upward.

Two forces are acting on the body A:

(i) Its weight $w_1 = m_1g$, acting downward.

(ii) Tension of string T, acting upward.

Since the body A moves downwards, hence its weight m_1g is greater than the tension T in the string.

$\therefore$ Net force acting on body A = $m_1g - T$

According to Newton's second law of motion;

$$m_1g - T = m_1a \quad \text{.........} \quad \text{(i)}$$

Two forces are acting on the body B:

(i) Its weight $w_2 = m_2g$, acting downward.

(ii) Tension in the string 'T', acting upward.

As body B moves upwards, hence its weight m_2g is less than the tension T in the string.

$\therefore$ Net force acting on body B = $T - m_2g$

According to Newton's second law of motion;

$$T - m_2g = m_2a \quad \text{.........} \quad \text{(ii)}$$

Adding Eq. (i) and Eq. (ii), we get acceleration a.

$$m_1g - m_2g = m_1a + m_2a$$

$$(m_1 - m_2)g = (m_1 + m_2)a$$

Magnitude of acceleration = $a = \frac{m_1 - m_2}{m_1 + m_2}g$ .... (iii)

Putting the value of 'a' in Eq.(ii) we get,

$$T - m_2g = m_2\left(\frac{(m_1-m_2)g}{m_1+m_2}\right)$$

$$T = m_2g + m_2\left(\frac{(m_1-m_2)g}{m_1+m_2}\right)$$

$$T = m_2g\left[1 + \frac{m_1-m_2}{m_1+m_2}\right]$$

$$T = m_2g\left[\frac{m_1+m_2+m_1-m_2}{m_1+m_2}\right]$$

Magnitude of tension = $T = \frac{2m_1 m_2}{m_1 + m_2}g$

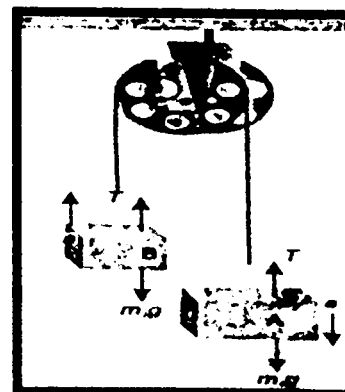
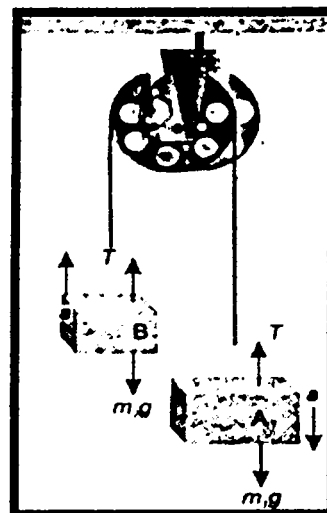
Note:

Atwood machine:

The above arrangement is also known as ***Atwood machine***. It can be used to find the acceleration g due to gravity using Eq. (iii),

$$g = \frac{m_1 + m_2}{m_1 - m_2}a$$

DO YOU KNOW

An Atwood machine is an arrangement of two objects of unequal masses such as shown in figure. Both the objects are attached to the ends of a string. The string passes over a frictionless pulley. This arrangement is sometime used to find the acceleration due to gravity.

Q19. Calculate the tension and acceleration in a string during motion of two bodies attached to the ends of a string that passes over a frictionless pulley such that one body moves vertically and the other moves on a smooth horizontal surface:

Ans: Motion of two bodies attached to the ends of a string that passes over a frictionless pulley such that one body moves vertically and the other moves on a smooth horizontal surface:

Consider two bodies A and B of masses m_1 and m_2 respectively attached to the ends of an inextensible string.

Let the body A moves downwards with an acceleration a. Since the string is inextensible, therefore, body B also moves over the horizontal surface with the same acceleration a. As the pulley is frictionless, hence tension T will be the same throughout the string.

Since body A moves downwards, therefore its weight m_1g is greater than the tension in the string.

$\therefore$ Net force acting on body A = $m_1g - T$

According to Newton's second law of motion;

$$m_1g - T = m_1a \qquad (i)$$

The forces acting on body B are:

i. Weight m_2g of the body B acting downward.

ii. Reaction R of the horizontal surface acting on body B in the upwards direction.

iii. Tension T in the string pulling the body B horizontally over the smooth surface.

As body B has no vertical motion, hence resultant of vertical forces (m_2g and R) must be zero. Thus the net force acting on body B is T.

According to Newton's second law of motion;

$$T = m_2a \qquad (ii)$$

Adding Eq. (i) and (ii), we get acceleration a as

$$m_1g - m_2a = m_1a$$

$$m_1g = m_1a + m_2a$$

$$m_1g = a(m_1 + m_2)$$

$$a = \frac{m_1}{m_1 + m_2}g \qquad (iii)$$

Putting the value of a in equation (ii), we get tension T as

Magnitude of tension $= T = \frac{m_1 m_2}{m_1 + m_2}g$

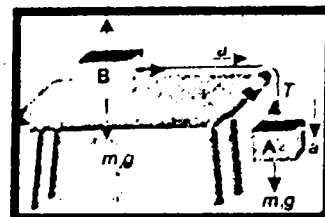
Q20. Show the relationship between momentum and force OR Drive Newton's Second Law of motion with the help of momentum.

OR

Prove that F = $\frac{\Delta P}{t}$.

OR

How can you relate a force with the change of momentum of a body?

Ans: See Q # 3.7 from Exercise

Q21. Show that Ns = Kg m/s OR Ns = Kg ms^{-1}

Ans: L.H.S = Ns = $(1kg \times 1ms^{-2}) \times s$ = $Kg \times ms^{-2+1}$
= $Kg \times ms^{-1}$ = Kg m/s

USEFUL INFORMATION

Fragile objects such as glass wares etc. are packed with suitable materials such as styrofoam rings, balls, polythene sheets with air sacks etc.

Air enclosed in the cavities of these materials makes them flexible and soft. During any mishap, they increase the impact time on fragile objects. An increase in impact time lowers the rate of change of momentum and hence lessens the impact of force. This lowers the possible damage due to an accident.

USEFUL INFORMATION

In an accident at high speed. the impact force is very large due to the extremely short stopping time. For safety purposes, vehicles have rigid cages for passengers with crumple zones at their front and rear ends.

During an accident, crumple zones collapse. This increases the impact time by providing extra time for crumpling. The impact of force is highly reduced and saves the passengers from severe injuries.

USEFUL INFORMATION

In case of an accident, a person not wearing seatbelt will continue moving until stopped suddenly by something before him. This something may be a windscreen, another passenger or back of the seat in front of him/her. Seatbelts are useful in two ways:

- They provide an external force to a person wearing seatbelt.
- The additional time is required for stretching seat belts. This prolongs the stopping time for momentum to change is and reduces the effect of collusion.

Q22. Define system and isolated system?

Ans: System:

A system is a group of bodies within certain boundaries.

Isolated system:

An isolated system is a group of interacting bodies on which no external force is acting. The momentum of an isolated system is always conserved. This is the Law of Conservation of Momentum.

Q23. What is the law of conservation of momentum?

OR

State and explain the law of conservation of momentum?

Ans: See Q # 3.11 from Exercise.

Q24. When a gun is fired, it recoils. Why?

Ans: See Q # 3.13 from Exercise.

Q25. Under which principle rockets and jet engines works?

Ans: Working of rockets and jet engines:

Rockets and jet engines also work on the same principle. In these machines, hot gases produced by burning of fuel rush out with large momentum. The machines gain an equal and opposite momentum. This enables them to move with very high velocities.

Q26. What do you know about friction?

Ans: Friction:

The force that opposes the motion of moving objects is called friction.

Friction is a force that comes into action as soon as a body is pushed or pulled over a surface.

Factor on which friction depends:

In case of solids, the force of friction between two bodies depends upon many factors such as nature of the two surfaces in contact and the pressing force between them.

Examples:

Rub your palm over different surfaces such as table, carpet, polished marble surface, brick, etc. You will find smoother is the surface, easier it is to move your palm over the surface. Moreover, harder you press your palm over the surface, more difficult would it be to move.

Q27. Have you noticed why a moving ball stops?

Ans: Moving ball stops due to force of friction.

Q28. Why bicycle stops when the cyclist stops peddling?

Ans: Bicycle stops due to force of friction.

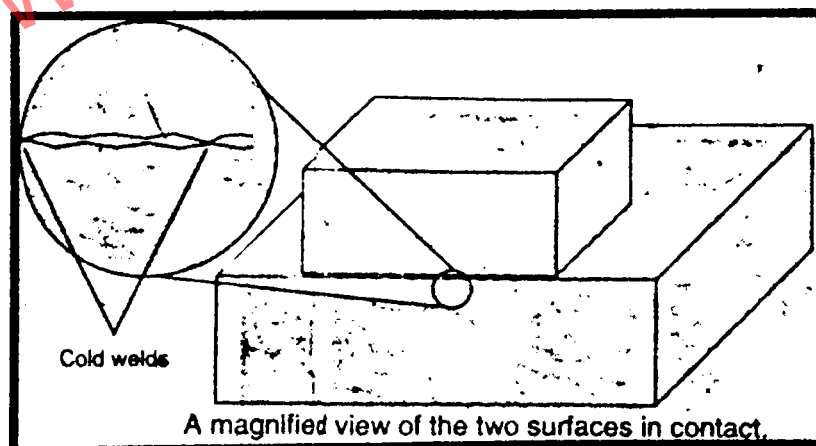
Q29. Why friction opposes motion?

OR

Give microscopic concept of friction?

Ans: Microscopic concept of friction:

No surface is perfectly smooth. A surface that appears smooth has pits and bumps that can be seen under a microscope. Figure shows two wooden blocks with their polished surfaces in contact.

A magnified view of the two surfaces in contact.

A magnified view of two smooth surfaces in contact shows the gaps and contacts between them. The contact points between the two surfaces form a sort of cold welds. These cold welds resist the surfaces from sliding over each other. Adding weight over the upper block increases the force pressing the surfaces together and hence increases the resistance. Thus, greater is the pressing force greater will be the friction between the sliding surfaces.

Tidbits

Pushing the opposite walls by palms and feet increases friction. This enables the boy to move up on the walls.

Q30. What you know about limiting force of friction?

Ans: See Q # 3.18 (ii) from Exercise.

Q31. What do you know about the coefficient of friction?

Ans: Coefficient of friction (μ):

The ratio between the force of limiting friction F_s and the normal reaction R is constant. This constant is called the coefficient of friction and is represented by μ

Thus $\mu = \frac{F_s}{R}$ (i)

or $F_s = \mu R$ .... (ii)

If m be the mass of the block, then for horizontal surface;

$R = mg$ (iii)

Hence $F_s = \mu mg$ (iv)

Q32. Describe two situations in which force of friction is needed.

Ans: See Q # 3.14 from Exercise.

Q33. Enlist coefficient of friction (μ) between some common materials?

Ans: Coefficient of friction (μ) between some common materials?

Materials	μ_s
Glass and Glass	0.9
Glass and Metal	0.5 - 0.7
Ice and Wood	0.05
Iron and Iron	1.0
Rubber and Concrete	0.6
Steel and Steel	0.8
Tyre and Road, dry	1
Tyre and Road, wet	0.2
Wood and Wood	0.25 - 0.6
Wood and Metal	0.2 - 0.6
Wood and Concrete	0.62

QUICK QUIZ

1. Which shoe offer less friction?

Ans: The smooth surface shoe offer less friction.

2. Which shoe is better for walking on dry track?

Ans: The smooth surface shoe is better for walking on dry track.

3. Which shoe is better for jogging?

Ans: The rough surface shoe is better for jogging.

4. Which sole will wear out early?

Ans: The smooth surface sole will wear out early.

Q34. Why rolling friction is less than sliding friction?

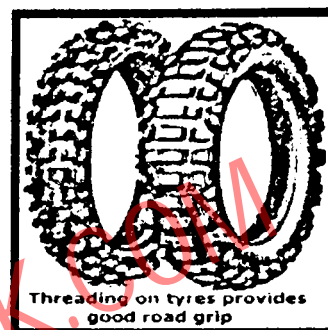
OR

Demonstrate that rolling friction is less than sliding friction?

Ans: See Q # 3.17 from Exercise.

Q35. The first thing about a wheel is that it rolls as it moves rather than to slide. This greatly reduces friction. Why?

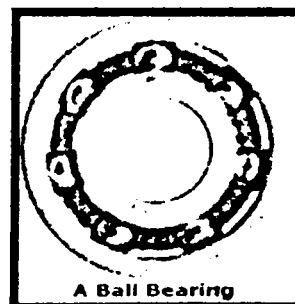
Ans: When the axle of a wheel is pushed, the force of friction between the wheel and the ground at the point of contact provides the reaction force. The reaction force acts at the contact points of the wheel in a direction opposite to the applied force. The wheel rolls without rupturing the cold welds. That is why the rolling friction is extremely small than sliding friction.

Threading on tyres provides good road grip

Q36. Why ball bearing or roller bearings are used to reduce friction?

Ans: The fact that rolling friction is less than sliding friction is applied in ball bearings or roller bearings to reduce losses due to friction.

A Ball Bearing

Q37. Friction is a 'necessary evil'. Comment.

Ans. In certain cases we need friction while in certain other we have to reduce friction. It means friction has some advantages as well as disadvantages. It is difficult to walk on ice because of less friction. A nail stays in the wood because of friction similarly we can tie a knot because of this force. A horse will not be able to pull a wagon unless friction furnishes him a secure foot-hold.

Friction causes energy lost and reduces the efficiency of machines. Friction causes rapid wear and tear.

In short we can say that friction is necessary for our every-day activities. Thus, the statement that "friction is necessary evil" is correct.

The wheel would not roll on pushing it if there would be no friction between the wheel and the ground. Thus, friction is desirable for wheels to roll over a surface.

Q38. Why it is dangerous to drive on a wet road?

It is dangerous to drive on a wet road because the friction between the road and the tyres is very small. This increases the chance of slipping the tyres from the road. The threading on tyres is designed to increase friction. Thus, threading improves road grip and make it safer to drive even on wet road.

Q39. Why a cyclist applies brakes to stop his/her bicycle?

Ans: A cyclist applies brakes to stop his/her bicycle.

As soon as brakes are applied, the wheels stop rolling and begin to slide over the road. Since sliding friction is [illegible] friction. Therefore, the [illegible]

QUICK QUIZ

1. Why is it easy to roll a cylindrical eraser on a paper sheet than to slide it?

Ans: The fact that rolling friction is less than sliding friction. Cylindrical eraser is a rolling body and can easily rolled on a paper sheet than to slide it. Because a rolling friction is the force of friction between a rolling body and a surface over which it rolles.

2. Do we roll or slide eraser to remove the pencil the work from our notebook?

Ans: The fact that sliding friction is greater than rolling friction. We slide the eraser to remove the pencil work from our note book.

Q40. Explain breaking force and skidding of vehicles?

Ans: See Q # 3.18 (iii & iv) from Exercise.

Mini Exercise

1. In which case do you need smaller force and why?

(i) rolling **(ii) sliding**

Ans: In case of rolling friction we need smaller force. Because the rolling friction is lesser than the sliding friction.

2. In which case it is easy for the tyre to roll over?

(i) rough ground **(ii) smooth ground**

Ans: On the smooth ground, it is easy for the tyre to roll over due to less friction.

Q41. Describe the situations in daily life in which friction is most desirable?

Ans: Sometimes friction is most desirable. We cannot write if there would be no friction between paper and the pencil. Friction enables us to walk on the ground. We cannot run on a slippery ground.

A slippery ground offers very little friction. Hence, anybody who tries to run on a slippery ground may meet an accident. Similarly, it is dangerous to apply brakes with full force to stop a fast moving vehicle on a slippery road.

Birds could not fly, if there is no air resistance. The reaction of pushed air enables the birds to fly. Thus in many situations, we need friction while in other situations we need to reduce it as much as possible.

Q42. Write a dream during which you are driving a car and suddenly the friction disappears. What happened next...?

Ans: If suddenly the friction disappear then we can not stop the car. Nothing would be steady on the ground, car would be just sliding and sliding.

Q43. Describe the advantages of friction?

Ans: **Advantages of friction in daily life:**

1. It enables animals to walk or crawl without slipping.
2. It stops cars, trains, bicycles, MRT trains etc.

3. It enables us to hold things firmly with our hands.
4. It prevents objects from sliding down a slope.
5. It allows nails to hold things.

Q44. What are the disadvantages of the friction?

Ans: Problems caused by friction:

1. It causes energy lost and reduces the efficiency of machines.
2. It causes rapid wear and tear of the moving parts of machines.

Most of our useful energy is lost as heat and sound due to the friction between various moving parts of machines. In machines, friction also causes wear and tear of their moving parts.

Q45. What are the methods to reduce friction?

Ans: See Q # 3.16 from Exercise.

DO YOU KNOW?

Friction is highly desirable when climbing up a hill.

Q46. Define uniform circular motion?

Ans: Uniform circular motion:

The motion of an object in a circular path is known as circular motion. Motion of the moon around the Earth is circular motion.

Q47. Define centripetal force. Derive the relation of centripetal force on a body moving in a circle?

Ans: Centripetal force:

Centripetal force is a force that keeps a body to move in a circle.
The centre seeking force is called the centripetal force. It keeps the body to move in a circle. Centripetal force always acts perpendicular to the motion of the body.

Examples:

Let us study the centripetal forces in the following examples:

(i) a stone tied to one end of a string rotating in a circle. The tension in the string provides the necessary centripetal force. It keeps the stone to remain in the circle. If the string is not strong enough to provide the necessary tension, it breaks and the stone moves away along a tangent to the circle.

Centripetal force acting on the stone and centrifugal the force acting on the string.

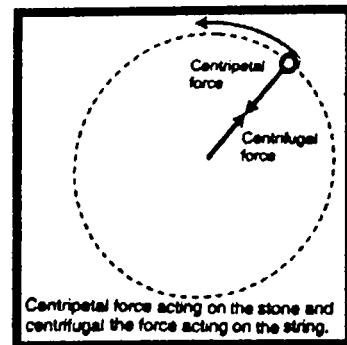
(ii) The moon revolves around the Earth. The gravitational force of the Earth provides the necessary centripetal force.

Derivation of centripetal force:

Let a body of mass m moves with uniform speed v in a circle of radius r. The acceleration a_c produced by the centripetal force F_c is given by

$$\text{Centripetal acceleration } a_c = \frac{v^2}{r} \qquad \text{......(i)}$$

According to Newton's second law of motion, the centripetal force F_c is given by

$$F_c = ma_c \qquad \text{(ii)}$$

$$F_c = \frac{mv^2}{r} \quad ...... (iii)$$

Factors on which centripetal force depends:

Equation $F_c = \frac{mv^2}{r}$ shows that the centripetal force needed by a body moving in a circle depends on:

- **i.** The mass m of the body.
- **ii.** Square of velocity v.
- **iii.** Reciprocal of the radius r of the circle.

Q48. What is centrifugal force? Explain.

Ans: Centrifugal force:

The centripetal force pulls the object towards the centre of the circle. As a reaction, another force appears at the centre of the circle which is equal in magnitude to the centripetal force but opposite in direction. This outward reaction is called centrifugal force.

According to Newton's third law of motion, there exists a reaction to this centripetal force. Centripetal reaction that pulls the string outward is sometimes called the centrifugal force.

Example:

If we whirl a piece of stone tied to one end of a string, the stone is pulled inwards due to the centripetal force transmitted to it through the string. As a reaction, the stone pulls our hand outwards, and this outward reaction force on our hand is the centrifugal force.

DO YOU KNOW?

While the coaster cars move around the loop, the track provides centripetal force preventing them to move away from the circle.

Q49. Identify the use of centripetal force in (i) safe driving by banking roads (ii) washing machine dryer (iii) cream separator.

Ans: i. Banking of the roads:

The curvature of the road must be inclined so as to control the Centrifugal force of the Vehicle.

Banking of road means to make the road to slide towards the center of curvature with an angle. It is helpful because if the velocity of car is more or there is less friction between the tyres and the road which reduce the danger of car to move out of circular track.

Outer edge of the curved road is elevated to prevent skidding.

Explanation:

When a car takes a turn, centripetal force is needed to keep it in its curved track. The friction between the tyres and the road provides the necessary centripetal force. The car would skid if the force of friction between the tyres and the road is not sufficient enough particularly when the roads are wet. This problem is solved by banking of curved roads.

ii. Washing machine dryer:

The dryer of a washing machine is basket spinners. They have a perforated wall having large numbers of fine holes in the

cylindrical rotor. The lid of the cylindrical container is closed after putting wet clothes in it. When it spins at high speed the water from wet clothes forced out through these holes due to lack of :

Figure: Dryer of washing machines has perforated wall.

iii. Cream separator:

Most modern plants use a separator to control the fat contents of various products. A separator is a high-speed spinner. It acts on the same principle of centrifuge machines. The bowl spins at very high speed causing the heavier contents of milk to move outward in the bowl pushing the lighter contents inward towards the spinning axis.

Cream or butterfat is lighter than other components in milk. Therefore, skimmed milk, which is denser than cream is collected at the outer wall of the bowl. The lighter part (cream) is pushed towards the centre from where it is collected through a pipe.

SUMMARY

1. A force is a push or pull. It moves or tends to move, stops or tends to stop the motion of a body.
2. **Inertia:** Inertia of a body is its property due to which it resists any change in its state of rest or uniform motion in a straight line.
3. **Momentum:** Momentum of a body is the quantity of motion possessed by the body. Momentum of a body is equal to the product of its mass and velocity
4. **Friction:** The force that opposes the motion of a body is called friction.
5. Newton's first law of motion: Newton's first law of motion states that a body continues its state of rest or of uniform motion in a straight line provided no net force acts on it.
6. **Newton's second law of motion:** Newton's second law of motion states that when a net force acts on a body, it produces acceleration in the body in the direction of the net force. The magnitude of this acceleration is directly proportional to the net force acting on it and inversely proportional to its mass. Mathematically, $F = ma$.

7. **Unit of Force:** SI unit of force is newton (N). It is defined as the force which produces an acceleration of 1 ms^{-2} in a body of mass 1 kg.
8. **Mass:** Mass of a body is the quantity of matter possessed by it. It is a scalar quantity. SI unit of mass is kilogramme (kg).
9. Weight: Weight of a body is the force of gravity acting on it. It is a vector quantity. SI unit of weight is newton (N).
10. **Newton's third law of motion:** Newton's third law of motion states that to every action there is always an equal and opposite reaction.
11. The acceleration and tension in a system of two bodies attached to the ends of a string that passes over a frictionless pulley such that, both move vertically are given by:
    $a = \frac{m_1 - m_2}{m_1 + m_2} g$; $T = \frac{2m_1 m_2}{m_1 + m_2} g$
12. The acceleration and tension in a system of two bodies attached to the ends of a string that passes over a frictionless pulley such that one moves vertically and the other moves on a smooth horizontal surface are given by:
    $a = \frac{m_1}{m_1 + m_2} g$ $T = \frac{m_1 m_2}{m_1 + m_2} g$
13. **Law of conservation of momentum:** Law of conservation of momentum states that the momentum of an isolated system of two or more than two interacting bodies remains constant.
14. **Friction:** A force between the sliding objects which opposes the relative motion between them is called friction.
15. **Rolling friction:** Rolling friction is the force of friction between a rolling body and a surface over which it rolls. Rolling friction is lesser than the sliding friction.
16. The friction causes loss of energy in machines and much work has to be done in overcoming it. Moreover, friction leads to much wear and tear on the moving parts of the machine. The friction can be reduced by:
    (i) Smoothing the sliding surfaces in contact.
    (ii) Using lubricants between sliding surfaces.
    (iii) Using ball bearings or roller bearings.
17. **Circular motion:** The motion of a body moving along a circular path is called circular motion.
18. **Centripetal force:** The force which keeps the body to move in a circular path is called the centripetal force and is given
    $F_c \quad \frac{mv_2}{r}$
19. **Centrifugal force:** According to Newton's third law of motion, there exists a reaction to this centripetal force. Centripetal reaction that pulls the string outward is sometimes called the centrifugal force.

QUESTIONS

3.1 Encircle the correct answer from the given choices:

i. Newton's first law of motion is valid only in the absence of:

A. force
B. net force
C. friction
D. momentum

ii. **Inertia depends upon**

A. force B. net force C. mass D. velocity

iii. **A boy jumps out of a moving bus. There is a danger for him to fall:**

A. towards the moving bus
B. away from the bus
C. in the direction of motion
D. opposite to the direction of motion

iv. **A string is stretched by two equal and opposite forces 10 N each. The tension in the string is.**

A. zero
B. 5N
C. 10 N
D. 20 N

v. **The mass of a body:**

A. decreases when accelerated
B. increases when accelerated
C. decreases when moving with high velocity
D. none of the above

vi. **Two bodies of masses m_1 and m_2 attached to the ends of an inextensible string passing over a frictionless pulling such that both move vertically. The acceleration of the bodies is:**

A. $\frac{m_1 \times m_2}{m_1 + m_2} g$
B. $\frac{m_1 - m_2}{m_1 + m_2} g$
C. $\frac{m_1 + m_2}{m_1 - m_2} g$
D. $\frac{2m_1 m_2}{m_1 + m_2} g$

vii. **Which of the following is the unit of momentum?**

A. Nm
B. $kgms^{-1}$
C. Ns
D. Ns^{-1}

viii. **When horse pulls a cart, the action is on the:**

A. cart
B. Earth
C. horse
D. Earth and cart

ix. **Which of the following material lowers friction when pushed between metal plates?**

A. water
B. fine marble powder
C. air
D. oil

Answers

i. B	ii. C	iii. C	iv. A	v. D
vi. B	vii. C	viii. D	ix. D	

3.2 Define the following terms:

(i) Inertia **(ii) Momentum** **(iii) Force**
(iv) Force of friction **(v) Centripetal force**

Ans: (i) Inertia:

Inertia of a body is its property due to which it any change in its state of rest or motion.

Galileo related the inertia of a body with its mass; greater is the mass of a body greater is its inertia.

Inertia ∝ mass of body

(ii) Momentum:

Momentum of a body is the quantity of motion it possesses due to its mass and velocity.

The momentum P of a body is given by the product of its mass m and velocity v, Thus

$$P = mv$$

Momentum is a vector quantity. Its SI unit is $kgms^{-1}$.

Momentum of a system depends on its mass and velocity.

(iii) Force:

A force moves or tends to move, stops or tends to stop the motion of a body. The force can also change the direction of motion of a body.

$$F = ma$$

SI unit of force is newton.

Note: A force can also change the shape or size of a body on which it acts.

(iv) Force of friction:

Friction:

The force that opposes the motion of moving objects is called friction.

Friction is a force that comes into action as soon as a body is pushed or pulled over a surface.

Factor on which friction depends:

In case of solids, the force of friction between two bodies depends upon many factors such as nature of the two surfaces in contact and the pressing force between them.

(v) Centripetal force:

Ans: Centripetal force:

Centripetal force is a force that keeps a body to move in a circle.

The centre seeking force is called the centripetal force. It keeps the body to move in a circle. Centripetal force always acts perpendicular to the motion of the body.

$$F_c = \frac{mv^2}{r}$$

3.3 What is the difference between:

(i) Mass and weight

(ii) Action and reaction

(iii) Sliding friction and rolling friction

Ans: (i) Mass and weight:

Mass	Weight
1. The quantity of matter contained in a body is called its mass.	**1.** Weight is the force with which earth attracts a body towards its centre.
2. The mass of a body remains constant everywhere, whether it is measured at a point far away from the centre of the earth, or on the surface at the centre of the earth.	**2.** The weight of a body is not constant quantity but its value is different at different places.

3. Mass is a scalar quantity.	**3.** Weight is a vector quantity and is always directed towards the centre of the earth.
4. The S.I. unit of mass is kilogram.	**4.** The S.I. unit of weight is Newton.
5. Mass is measured by ordinary balance.	**5.** Weight is measured by spring balance
6. mass of the body cannot be zero	**6.** Weight of the body can be zero i.e. at the centre of the earth and in space where g= 0. So $W = mg = m \times 0 = 0$
7. It is the measure of inertia in a body. i.e. $m = \frac{W}{g}$	**7.** Weight is given by $W = mg$

(ii) Action and reaction:

Newton's third law of motion deals with the reaction of a body when a force acts on it. Let a body A exerts a force on another body B, the body B reacts against this force and exerts a force on body A. The force exerted by body A on B is the **action force** whereas the force exerted by body B on A is called the reaction **force.**

Note that action and reaction forces act on different bodies.

Example:

Action and reaction forces act on different objects, and in opposite directions. For example, if the rocket pushes the gas out, the gas pushes back against the rocket. The forces are on different objects (the gas, and the rocket, respectively), and in opposite directions.

(iii) Sliding friction and rolling friction:

Sliding friction:

A force between the sliding objects which opposes the relative motion between them is called sliding friction.

Rolling friction:

Rolling friction is the force of friction between a rolling body and a surface over which it rolls. Rolling friction is lesser than the sliding friction.

3.4 What is the law of Inertia?

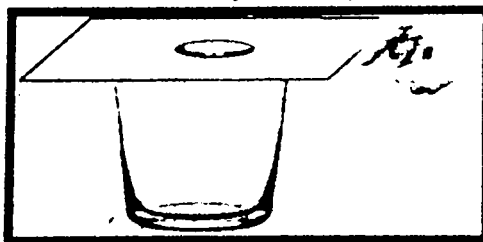
Ans: Inertia:

Inertia of a body is its property due to which it any change in its state of rest or motion.

Galileo related the inertia of a body with its mass; greater is the mass of a body greater is its inertia.

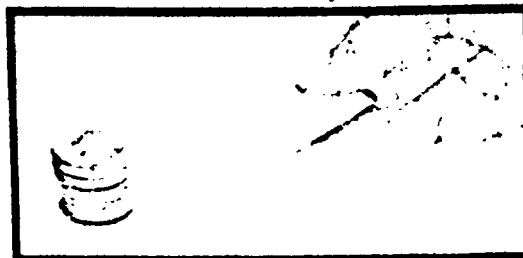
Inertia ∝ mass of body

Experiment:

Take a glass and cover it with a piece of cardboard. Place a coin on the cardboard. Now kick the card horizontally with a jerk of your finger.

The coin falls into the glass as the card flicks away

The coin does not move with the cardboard due to inertia. The coin falls into the glass as the card flicks away.

Experiment:

Cut a strip of paper. Place it on the table. Stack a few coins at its one end. Pull out the paper strip under the coins with a jerk.

Coins stacked over remain undisturbed on pulling the paper strip quickly

Coins staked over remain undisturbed on pulling the paper strip quickly due to inertia.

3.5 Why is it dangerous to travel on the roof of a bus?

Ans: Because the friction force due air acting on the upper part of body the person who travelling on the roof of the running bus try to turn over which is dangerous for passenger while the lower portion remain at rest w.r.t. the roof of the bus due to inertia.

3.6 Why does a passenger move outward when a bus takes a turn?

Ans: An inward net force is required to make a turn in a circle. This inward net force requirement is known as a centripetal force requirement. In the absence of any net force, an object in motion (such as the passenger) continues in motion in a straight line at constant speed. Due to the absence of necessary centripetal force a passenger moves outward when a bus takes a turn.

3.7 How can you relate a force with the change of momentum of a body?

Ans: Force and the momentum:

Consider a body of mass m moving with initial velocity v_i. Let a force F acts on the body which produces an acceleration a in it. This changes the velocity of the body. Let its final velocity after time t becomes v_f. If P_i, and P_f be the initial momentum and final momentum of the body related to initial and final velocities respectively then

$$P_i = mv_i$$

and

$$P_f = mv_f$$

Change in momentum = final momentum – initial momentum

or P_f [illegible]

Thus the rate of change in momentum is given by:

$$\frac{P_f - P_i}{t} = \frac{mv_f - mv_i}{t}$$

Since $\frac{v_f - v_i}{t}$ is the rate of change of velocity equal to the acceleration a produced by the force F.

$$\frac{P_f - P_i}{t} = ma$$

According to Newton's second law of motion,

$$F = ma$$

or $$\frac{P_f - P_i}{t} = F \quad \ldots\ldots\ldots\ldots (i)$$

Equation (i) also defines force and states Newton's second law of motion as:

When a force acts on a body, it produces an acceleration in the body and will be equal to rate of change of momentum of the body.

3.8 What will be the tension in a rope that is pulled from its ends by two opposite forces 100 N each?

Ans: Tension in the rope and its force pulls equally at both the ends. If no forces are acting on the rope except its ends, and the rope itself being in equilibrium, then the tension is the same throughout the rope.

$$\sum F = 0$$

3.9 Action and reaction are always equal and opposite. Then how does a body moves?

Ans: Actions and reactions (forces acting on an object) are equal and opposite when the object is at equilibrium. When we apply external force to pull, push and twist, the equilibrium is disturbed means, now the magnitude of action (force provided by you) and reaction (force provided by the objects) is not equal. That is why it is possible to twist, pull, move and push the object in the direction of applied force.

3.10 A horse pushes the cart. If the action and reaction are equal and opposite then how does the cart move?

Ans: First of all when the horse pulls on the cart, the cart exerts an equal but opposite reaction on the horse, the action and reaction. If this was the only force in action then the horse and cart would indeed remain stationary.

However there is another force between the horse and the ground. The horse's hooves press down on the ground and the ground pushes back on the horse.

If the reaction force of the ground is greater than the reaction force of the cart on the horse, then the horse will move forward. The cart will move forward when the force exerted on it by the horse is greater than the frictional force between the cart and the ground.

3.11 What is the law of conservation of momentum?

Ans: Law of conservation of momentum:

The momentum of an isolated system of two or, more than two interacting bodies remains constant.

Examples:

Consider the example of an air-filled balloon as described under the third law of motion. In this case, balloon and the air inside it form a system. Before releasing the balloon, the system was at rest and hence the initial momentum of the system was zero. As soon as the balloon is set free, air escapes out of it with some velocity. The air coming out of it possesses momentum. To conserve momentum, the balloon moves in a direction opposite to that of air rushing out.

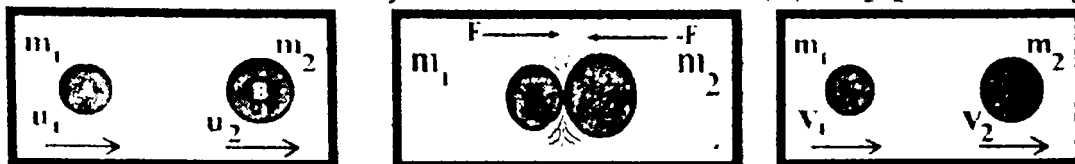
Explanation:

Case I:

Consider an isolated system of two spheres of masses m_1 and m_2. They are moving in a straight line with initial velocities u_1 and u_2 respectively such that u_1 is greater than u_2. Sphere of mass m_1 approaches the sphere of mass m_2 as they move.

Initial momentum of mass $m_1 = m_1u_1$

Initial momentum of mass $m_2 = m_2u_2$

Total initial momentum of the system before collision = $m_1u_1 + m_2u_2$ .... (i)

Case II:

After sometime mass m_1 hits m_2 with some force. According to Newton's third law of motion, m_2 exerts an equal and opposite reaction force on m_1 Let their velocities become v_1 and v_2 respectively after collision. Then

Final momentum of mass $m_1 = m_1v_1$

Final momentum of mass $m_2 = m_2v_2$

Total final momentum of the system after collision = $m_1v_1 + m_2v_2$ .... (ii)

According to the law of conservation of momentum

$$\begin{bmatrix}\text{Total initial momentum of} \\ \text{The system before collision}\end{bmatrix} = \begin{bmatrix}\text{Total final momentum of} \\ \text{the system after collision}\end{bmatrix}$$

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2 \qquad \text{(iii)}$$

Equation (iii) shows that the momentum of an isolated system before and after collisions remains the same which is the law of conservation of momentum. Law of conservation of momentum is an important law and has vast applications.

3.12 Why is the law of conservation of momentum important?

Ans: Law of conservation of momentum is applicable on all objects in the universe. A rocket and jet engine taking off, the recoil of a gun, and a bank-shot in a pool are examples which demonstrate the importance of law of conservation of momentum.

3.13 When a gun is fired, it recoils. Why?

Ans: Recoil of gun:

Consider a system of gun and a bullet. Before firing the gun, both the gun and bullet are at rest, so the total momentum of the system is zero. As the gun is fired, bullet shoots out of the gun and acquires momentum. To conserve momentum of the system, the gun recoils.

According to the law of conservation of momentum, the total momentum of the gun and the bullet will also be zero after the gun is fired. Let m be the mass of the bullet and v be its velocity on firing the gun; M be the mass of the gun and V be the velocity with which it recoils. Thus the total momentum of the gun and the bullet after the gun is fired will be;

$$\begin{bmatrix}\text{Total momentum of the} \\ \text{gun and the bullet after} \\ \text{the gun is fired}\end{bmatrix} = MV + mv \; \ldots\ldots\ldots \text{(i)}$$

According to the law of conservation of momentum

$$\begin{pmatrix}\text{Total momentum of the}\\ \text{gun and the bullet after}\\ \text{the gun is fired}\end{pmatrix} = \begin{pmatrix}\text{Total momentum of the}\\ \text{gun and the bullet before}\\ \text{the gun is fired}\end{pmatrix}$$

$MV + mv = 0$

or $MV = -mv$

Hence. $V = \frac{m}{M}v$ (ii)

Equation (ii) gives the velocity V of the gun. Negative sign indicates that velocity of the gun is opposite to the velocity of the bullet, i.e., the gun recoils. Since mass of the gun is much larger than the bullet, therefore, the recoil is much smaller than the velocity of the bullet.

3.14 Describe two situations in which force of friction is needed.

Ans: **i.** Friction is needed to walk on the ground.

ii. It is risky to run on wet floor with shoes that have smooth soles. Athletes use special shoes that have extraordinary ground grip. Such shoes prevent them from slipping while running fast.

iii. To stop our bicycle we will apply brakes. The rubber pads pressed against the rims provide friction. It is the friction that stops the bicycle.

3.15 How does oiling the moving parts of a machine lowers friction?

Ans: The friction can be reduced by lubricating the sliding surfaces.

The oil helps slick (polished) the two surfaces so that the molecular surfaces become easier to slide on with less friction.

3.16 Describe ways to reduce friction.

Ans: Methods of reducing friction:

(i) The friction can be reduced by making the sliding surfaces smooth.

(ii) The friction can be reduced by making the fast moving objects a streamline shape (fish shape) such as cars, aeroplanes, etc. This causes the smooth flow of air and thus minimizes air resistance at high speeds.

(iii) The friction can be reduced by lubricating the sliding surfaces.

(iv) The friction can be reduced by using ball bearings or roller bearings. Because the rolling friction is lesser than the sliding friction.

3.17 Why rolling friction is less than sliding friction?

Ans: Sliding friction:

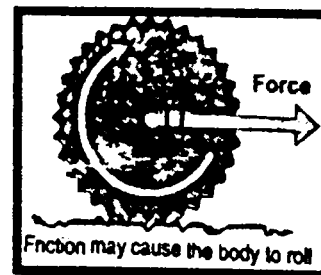
A force between the sliding objects which opposes the relative motion between them is called sliding friction.

Rolling friction:

Rolling friction is the force of friction between a rolling body and a surface over which it rolls. Rolling friction is lesser than the sliding friction.

Explanation:

When a certain body rolls over the surface of another body, it has the contact with the surface only at a single point. As there is no relative motion between the two bodies at this point, therefore, sliding friction is zero. However, practically, the wheel is compressed a little temporarily at the contact point of the two surfaces under pressure. Because of that little sliding friction, the rolling friction is

Friction may cause the body to roll

produced.

But when a body moves over the surface of another body, there is relative motion between the two surfaces, thus, friction has some maximum value. That is why the rolling friction is less than sliding friction. The rolling friction is 100 times less than sliding friction.

3.18 What you know about the following:

(i)	**Tension in a string**	**(ii)**	**Lim iting force of friction**
(iii)	**Braking force**	**(iv)**	**Skidding of vehicles**
(v)	**Seatbelts**	**(vi)**	**Banking of roads**
(vii)	**Cream separator**		

Ans: (i) Tension in a string

"The force exerted by a string when it is subjected to pull is called tension in the string".

If a person is holding a block of weight W attached to the end of a string, a force is experienced by him. This force is known as Tension. When the body is at rest, the magnitude of tension is equal to the weight of the body suspended by the string. Tension and the weight acts in the opposite direction.

T

W

Unit of Tension:

In S.I. system: newton

In C.G.S. system: dyne

In F.P.S. system: pound

(ii) Limiting force of friction

The maximum value of friction is known as the force of limiting friction (F_s). It depends on the normal reaction (pressing force) between the two surfaces in contact. $F_s = \mu R$

(iii) Braking force

Friction between a rotating component (the drum or disc) and a stationary component (the brake shoe or pad) causes the drum or disc to slow down such a force is called braking force.

There are four main aspects which will determine the amount of braking force that a system can generate:

i. The diameter of the disc

ii. The friction material

iii. The size of the pad friction face

iv. The force used to clamp the pads onto the disc

The greater the diameter of the disc, the further from the centre of the wheel the braking force can be applied. This in turn will generate a greater braking force, or torque, on the disc.

(iv) Skidding of vehicles

Skids usually occur while driving when the clutch is suddenly engaged or disengaged, the brakes are applied too hard, the vehicle accelerates too quickly or the steering wheel is turned too sharply. These can create a situation where power, either too much or too little, causes a loss of traction.

If the brakes are applied too strongly, the wheels of the car will lock up (stop turning) and the car will skid due to its large momentum. It will lose its directional control that may result in an accident. In order to reduce the chance of skidding, it is

advisable not to apply brakes too hard that lock up their rolling motion especially at high speeds.

(v) Seatbelts

In case of an accident, a person not wearing seatbelt will continue moving until stopped suddenly by something before him. This something may be a windscreen, another passenger or back of the seat in front of him/her. Seatbelts are useful in two ways:

- They provide an external force to a person wearing seatbelt.
- The additional time is required for stretching seat belts. This prolongs the stopping time for momentum to change is and reduces the effect of collusion.

(vi) Banking of roads

The curvature of the road must be inclined so as to control the Centrifugal force of the Vehicle.

Banking of road means to make the road to slide towards the center of curvature with an angle. It is helpful because if the velocity of car is more or there is less friction between the tyres and the road which reduce the danger of car to move out of circular track.

Explanation:
When a car takes a turn, centripetal force is needed to keep it in its curved track. The friction between the tyres and the road provides the necessary centripetal force. The car would skid if the force of friction between the tyres and the road is not sufficient enough particularly when the roads are wet. This problem is solved by banking of curved roads.

Outer edge of the curved road is elevated to prevent skidding.

(vii) Cream separator

Most modern plants use a separator to control the fat contents of various products. A separator is a high-speed spinner. It acts on the same principle of centrifuge machines. The bowl spins at very high speed causing the heavier contents of milk to move outward in the bowl pushing the lighter contents inward towards the spinning axis.

Cream or butterfat is lighter than other components in milk. Therefore, skimmed milk, which is denser than cream is collected at the outer wall of the bowl. The lighter part (cream) is pushed towards the centre from where it is collected through a pipe.

3.19 What would happen if all friction suddenly disappears?

Ans: If there was no friction then we could not walk, we would keep slipping. Nothing would be steady on the ground, many things would be just sliding and sliding.

3.20 Why the spinner of a washing machine is made to spin at a very high speed?

Ans: The dryer of a washing machine is basket spinners. They have a perforated wall having large numbers of fine holes in the cylindrical rotor. The lid of the cylindrical container is closed after putting wet clothes in it. When it spins at high speed, the water from wet clothes is forced out through these holes due to lack of centripetal force.

PROBLEMS

3.1 A force of 20 N moves a body with an acceleration of 2 ms^{-2}. What is its mass? (10 kg)

Solution:

Force = F = 20 N

Acceleration = a = 2 ms^{2}

Mass = m = ?

F = ma

or $m = \frac{F}{a}$

$m = \frac{20}{2}$ = 10 kg

3.2 The weight of a body is 147 N. What is its mass? (Take the value of g as 10 ms^{-2}) (14.7 kg)

Solution:

Weight = w = 147 N

Acceleration due to gravity = g = 10 ms^{-1}

Mass m = ?

w = mg

or $m = \frac{w}{g}$

$m = \frac{147}{10}$

m = 14.7 kg

3.3 How much force is needed to prevent a body of mass 10 kg from falling? (100 N)

Solution:

Mass = m = 50 kg

Acceleration = a = g = 10 ms^{-2}

Force = F = ?

F = ma

F = 10×10

F = 100 N

3.4 Find the acceleration produced by a force of 100 N in a mass of 50 kg. (2 ms^{-2})

Solution:

Force = F = 100 N

Mass = m = 50 kg

Acceleration = a = ?

F = ma

or $a = \frac{F}{m}$

$a = \frac{100}{50}$

a = 2 ms^{-2}

3.5 A body has weight 20 N. How much force is required to move it vertically upwards with an acceleration of 2 ms^{-2}? (24 N)

Solution: Weight = w = 20 N

Acceleration = a = 2 ms^{-2}

Vertically upward force (tension) = T = ?

$F_{net} = T - w$

or $ma = T - mg$

or $ma + mg = T$

or $T = m(a + g)$ .... (i)

Now, $m = \frac{w}{g}$

$m = \frac{20}{10} = 2$ kg

Putting the value of m in Eq.(i), we get

$T = 2(2 + 10)$

$= 2(12)$

$T = 24N$

3.6 Two masses 52 kg and 48 kg are attached to the ends of a string that passes over a frictionless pulley. Find the tension in the string and acceleration in the bodies when both the masses are moving vertically. (500 N, 0.4 ms^{-2})

Solution: $m_1 = 52$ kg and $m_2 = 48$ kg

(i) Tension T = ?

(ii) Acceleration a = ?

(i) $T = \frac{2m_1m_2}{m_1 + m_2} g$

$T = \frac{2 \times 52 \times 48}{52 + 48} \times 10$

$T = \frac{49920}{100}$

$T = 499.20 \approx 500$ N

(ii) $a = \frac{m_1 - m_2}{m_1 + m_2} g$

$a = \frac{52 - 48}{52 + 48} \times 10$

$a = \frac{4}{100} \times 10$

$a = 0.4\ ms^{-2}$

3.7 Two masses 26 kg and 24 kg are attached to the ends of a string which passes over a frictionless pulley. 26 kg is lying over a smooth horizontal table. 24 N mass is moving vertically downward. Find the tension in the string and the acceleration in the bodies.

(125 N, 4.8 ms^{-2})

Solution: $m_1 = 24$kg and $m_2 = 26$kg

(i) Tension in string T = ?

(ii) Acceleration a = ?

(i) $T = \frac{m_1m_2}{m_1 + m_2} g$

$T = \frac{24 \times 26}{24 + 26} \times 10 = \frac{6240}{50} = 124.8 \approx 125$ N

(ii) $a = \frac{m_1}{m_1 + m_2} g$

$a = \frac{24}{24 + 26} \times 10 = \frac{24}{50} \times 10 = 4.8\ ms^{-2}$

3.8 How much time is required to change 22 Ns momentum by a force of 20 N? (1.1 s)

Solution: Change in momentum = $P_f - P_i$ = 22 Ns

Force = F = 20N

Time = t = ?

$F = \frac{P_f - P_i}{t}$

or $t = \frac{P_f - P_i}{F}$

$t = \frac{22}{20} = 1.1\ s$

3.9 How much is the force of friction between a wooden block of mass 5 kg and the horizontal marble floor? The coefficient of friction between wood and the marble is 0.6. (30 N)

Solution: Mass = m = 5kg

Coefficient of friction = μ = 0.6

Force of friction = F_s = ?

$F_s = \mu R$ (where R = mg)

$F_s = \mu mg$

$F_s = 0.6 \times 5 \times 10 = 30\ N$

3.10 How much centripetal force is needed to make a body of mass 0.5 kg to move in a circle of radius 50 cm with a speed 3 ms^{-1}? (9 N)

Solution: Mass = m = 0.5 kg

Radius of the circle = r = 50 cm = $\frac{50}{100}$ = 0.5 m

Speed = v = 3 ms^{-1}

Centripetal force = F_c = ?

$F_c = \frac{mv^2}{r}$

$F_c = \frac{0.5 \times 3^2}{0.5}$

$= \frac{0.5 \times 9}{0.5} = \frac{4.5}{0.5} = 9\ N$